SETTING THE TONE: CONSIDERATIONS FOR EDUCATING THE NEXT GENERATION OF SOUND REPRODUCTION PROFESSIONALS

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1   INTRODUCTION

The number of formal educational programmes that include sound reproduction as an area of study can be difficult to deduce due to differences in the use of terminology and the handling of search data through various online course databases. In addition, sound reproduction is typically included in programmes such as Audio Engineering, Sound Technology or Music technology, which further adds to the difficulty in determining the extent of its inclusion. For instance, performing a search for 'Music Technology' through UCAS returns 80 institutions delivering undergraduate courses related to this title[1]. Searches for 'Sound' and 'Audio' return 58 and 66 providers respectively. In its most recent directory, UKMusic.org lists over 1200 formal music courses at FE and HE level[2] that include elements of sound reproduction. On closer inspection of some of these courses it becomes clear that they also incorporate aspects of music, audio, sound, technology, engineering, and production. Most notable are the number of Music Technology programmes that include elements of sound reproduction, but two courses sharing the same course title often include differing amounts of sound reproduction content with varying opportunities for technical and practical study or skills development.

1.1   Education and The Creative Industries

Various institutions and organisations view formal education programmes as a route into employment in the 'creative industries'[3] which include the industries of film, video games and music. Recent studies highlighted some of the issues that the creative industries face, for instance the skills shortage of technically proficient young people in the games industry in the UK caused predominantly through: 'A failing of our education system – from schools to universities – and it needs to be tackled urgently if we are to remain globally competitive'[4] Furthermore, the Skillset Skills Group report, commissioned by The Creative Industries Council (CIC) in 2011, declared that: 'An emphasis on studying academic subjects at school and university, while rigorous, risks young people missing out on those which have the potential to enrich their creative practice and become multi-talented professionals best able to exploit the new digital technologies, media platforms and tools that are becoming available'[5]. However, the same report emphasised that: 'too many courses produce graduates with insufficient specialisms to meet sector needs', which suggests a conflict between the breadth of education and the specificity of education.

The Skillset Group built on this 2011 study with their Report To the Creative Industries Council in 2012. This identifies a number of challenges faced by the creative industries leading to a range of recommendations and guidance. Among these recommendations are that 'industry relevant HE provision genuinely simulates the workplace' and 'within the UK's universities and research institutions, there should be greater synergy and exchange between STEM subjects (science, technology, engineering and maths) and the arts and creative industries. The report also highlights the need to 'develop a skilled technical workforce in music, where a growth in employment is predicted' and a need for technical skills in other areas such as performing arts, television and

digital media[6]. Educational programmes in this area are therefore required to be multi-faceted, up-to-date, include established as well as cutting edge content and meet the needs of industry at a given point in time. The president of Universities UK, Sir Christopher Snowden, further adds however that studying at University isn't simply a means to gaining employment and explains: 'I still very much believe there is a significant lifetime benefit to be got from going to university'[7].Therefore educational programmes must also be designed to provide a pathway for lifelong learning or continuing formal education in addition to meeting the needs of industry.

In what follows are some of the challenges and considerations in designing and delivering the sound reproduction subject area in a formal educational setting, using the BSc (Hons) Music Technology course at Leeds Metropolitan University as a case study. Beginning with an evaluation of the curriculum and some of the pedagogical approaches employed, the discussion then turns to the experiences of students who have studied the related modules and the ways in which the required skills and knowledge for industry have been addressed.

2   CURRICULM DESIGN

2.1   Course Level Curriculum - BSc (Hons) Music Technology

The BSc (Hons) Music Technology degree programme at Leeds Metropolitan University has been established for around 17 years and presently has approximately 300 students across the 3 years of the degree. The course is a valuable case study for discussion of some of the issues discussed in the previous section. One of the key challenges for the course is how to provide the breadth of subjects to allow for a range of careers in the creative industries yet still produce graduates with the depth of understanding required for technical careers in sound reproduction.

The curriculum for the course has recently undergone a refocus in which subject themes were created to help provide pathways of development through each academic level. These are Audio Engineering, Acoustics, Recording Practice, Computer Music, Critical Studies and Professional Practice as shown in Figure 1.

Course Theme	Year 1	Year 2	Year 3
Acoustics	Acoustics & Critical Listening	Acoustics and Psychoacoustics	Applied Acoustics
Critical Studies	Music in Context	Music Industry	*Contemporary Music in Context* *Music Technology in the Community*
Audio Engineering	**Analogue and Digital Audio Systems**	**Audio System Design** *Live Sound*	**Sound Reproduction Systems** *Spatial Audio*
Recording Practice	Audio Production Techniques Audio Production Practice	Studio Recording Techniques *Mixing and Mastering* *Post Production*	
Computer Music	Creative Audio Programming	Audio Software Systems *Interactive Audio Systems*	*Game Audio* *Audio Visual Interfaces* *Experimental Music Systems* *Electroacoustic Composition*
Professional Practice			Music Technology Project

(Figure 1 – BSc (Hons) Music Technology Themed Curriculum – Optional Modules in Italics)

The curriculum redevelopment has taken place at the same time as other changes in the Higher Education sector in England, namely the change in tuition fee structures and an increased impetus for educational programmes to evidence how they prepare graduates for employment in the industry.

Therefore the content and design of the BSc (Hons) Music Technology course has been carefully considered with an attempt to balance the demands of the industry and the educational expectations of the students. The course themes represent well established curriculum areas in Music Technology and, as well as providing clear pathways for students, are clearly present to reassure employers that students have been through a well structured programme. Within these general themes the course also features more specific topics, such as Game Audio and Spatial Audio, as a response to new developing areas in the professional audio industry.

2.2 Module Level Curriculum – Audio System Design

The Audio System Design Module is a key module in the Audio Engineering pathway on the BSc (Hons) Music Technology course and is delivered in the second semester of the second year. It has been chosen for discussion as it is indicative of the course ethos particularly with respect to audio engineering and sound reproduction issues. How this module serves both the students needs, the expectations of industry and how it fits in with the wider curriculum are also of interest.

The module aim as written in the module specification is as follows:

'This module aims to introduce students to the fundamental concepts associated with audio systems. Students will be able to describe the design and performance of audio equipment and take measurements of these pieces of equipment. Students will be able to use their understanding of this information in order to discuss the implications of various devices on audio quality in a complex audio signal chain'.

At the end of the module students will be expected to be able to:

1. Demonstrate a theoretical understanding of the common concepts associated with analogue and digital audio system design
2. Interpret published and measured performance parameters and specifications
3. Discuss subjective and objective audio performance

The module features a weekly lecture that covers underpinning theory and a weekly laboratory-style session. The laboratory-style session is a mixture of demonstration, discussion and directed tasks in order to usefully engage students in a number of ways. It is important for the success of these sessions for staff to be able to engage students with some discussion of the background behind the task and to give valuable context for the activity.

The Audio System Design module curriculum considers the audio signal path from source to destination, with a focus on issues of signal quality throughout the signal chain. Previous studies have shown that listening is a useful way of engaging students in technical discussion and issues of audio quality (Thompson, et al, 2013) and students are encouraged to listen to, as well as empirically analyse, the output of an audio signal chain. The module therefore begins by considering the end of the signal chain in the form of loudspeaker design (drivers, enclosures and amplification) and sound reproduction issues. As well as being a key industry expectation, the topic of sound reproduction is also one of the most accessible as all students have experiences of sound reproduction that can be directly applied to it study and this is used as a means to engage students in critical discussion from the outset.

	Lecture Topic	Laboratory
1	Loudspeaker Design - Drivers	Introduction to the module - Loudspeaker demo and listening exercises
2	Loudspeaker Design - Enclosures	Loudspeaker Lab 1 – Frequency response on and off axis
3	Loudspeaker Design - Amplification	Loudspeaker Lab 2 - Placement
4	Amplifier Design	Loudspeaker Lab 3 – Crossover networks
5	Audio Specifications - Distortion	Loudspeakers Review
6	Audio Specifications - Frequency Response	Audio Performance Lab 1 – EQ Measurement and performance
7	Audio Specifications - Noise Issues	Audio Performance Lab 2 – Outboard audio measurement and evaluation
8	Digital Audio Fundamentals -	Audio Performance Lab 3 – Digital Audio Performance
9	Digital Audio - Advanced topics	Microphone workshop – design, construction and performance
10	Impedance and Interfacing	Compression workshop – concepts, topology and performance
11	Revision	Solid State and Valve Electronics workshop – concepts, topology and performance
12	Revision	Test Revision Session
13	Test	

(Figure 2 – Audio System Design Module Schedule)

The middle part of the module considers audio specifications in the electrical domain and the final section of the module considers more specific topics such as impedance, valve electronics, interfacing and compression. Student activities take the form of a series of structured practical laboratory tasks, which explore key theories and practices, and students are required to write up two of these laboratory investigations as formal reports. The module concludes with a multiple-choice test in which students are encouraged to apply rather than recall their skills and knowledge. Listening is encouraged throughout the module and helps to reinforce the idea that sound reproduction principles can be studied using scientific methods of prediction, testing and measurement alongside subjective methods of listening.

The module has the following outcomes, which are intended to both support further study and acknowledge the requirements of industry and therefore students will have:

- Used industry standard handheld sound level meters and analysers
- Measured industry standard metrics for audio performance
- Listened to and measured the output of loudspeakers
- Manipulated audio signal paths and measured the impact of this
- Communicated a complex investigation in writing as a formal report
- Interpreted and evaluated published specification sheets for audio devices

2.3   Examples of Teaching and Learning

A fundamental aspect of loudspeaker design, and one of the most significant factors in the quality of the output of any multiple driver loudspeaker, is crossover network design. In the vast majority of loudspeaker designs the crossover is an analogue filter circuit and student activities in this area have traditionally seen students building their own crossover network from scratch, or modifying an off the shelf design. Both of these approaches have limitations on the complexity of the design and the number of parameters that can be easily modified. Furthermore, the manipulation of electrical circuits in this way is also time consuming and difficult to set up.

The module team wanted to get students to be in a position where they could quickly modify the key parameters of a crossover network in order to quickly assess the impact of these changes on the output of the loudspeaker. With many loudspeaker (and loudspeaker system) manufacturers starting to use digital crossover techniques in commercial designs it seemed appropriate to investigate a digital solution to this issue.

Max MSP was used to develop a standalone piece of software that could be used to drive a small 2 way loudspeaker. The software consisted of a basic audio player that could generate sine and noise test signals and also load user WAV files. This audio was then routed through a 2 way digital crossover network, which allowed manipulation of the following parameters: Crossover frequency Filter Topology, Delay (ms), Polarity, Gain and Filter Order for each filter element. A graphical display gave students visual feedback on the impact of their choices on the two filter responses.
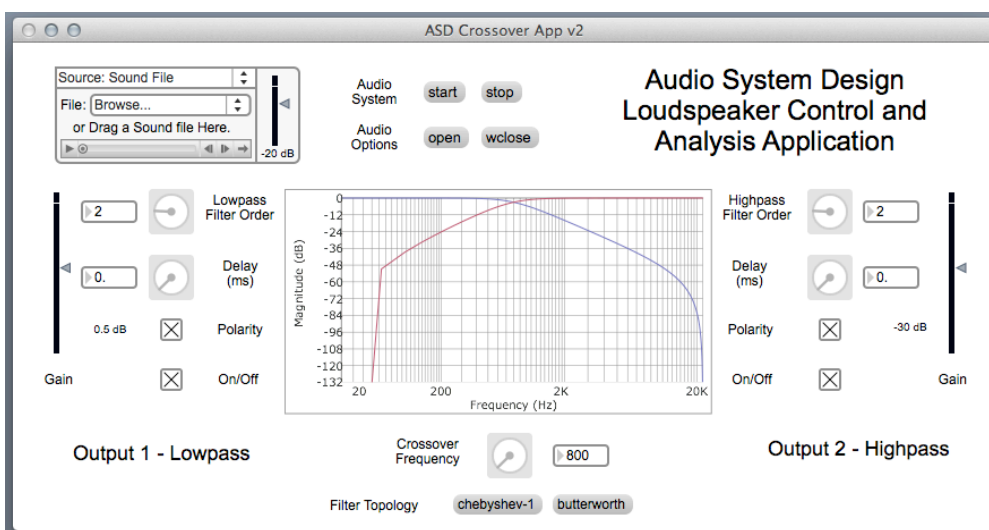
(Figure 3 – The Audio System Design Loudspeaker Control and Analysis Application)

The low-pass and high-pass outputs from the software were sent via an audio interface to two channels of an analogue amplifier and used to drive the woofer and tweeter of a small 2-way hi-fi loudspeaker. A test microphone running into an FFT analyser allowed students to immediately see the impact of the changes that were being made in the crossover software.
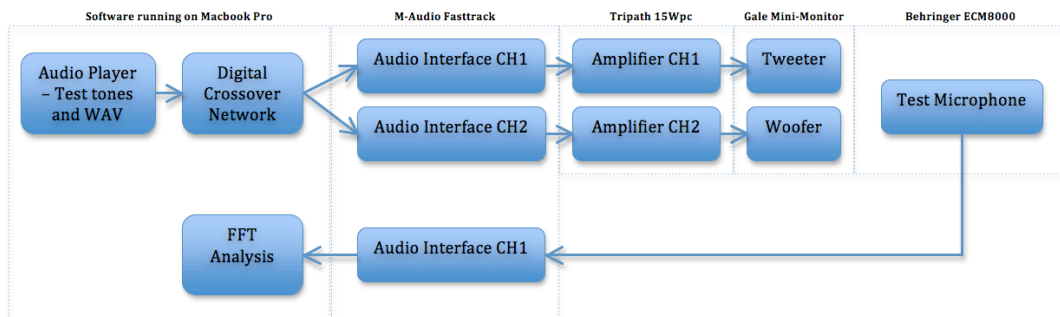
(Figure 4 – The Audio System Design Crossover Lab Exercise Signal Routing)

The students were asked to carry out several tasks. The most notable of these were to adjust the crossover setting to achieve the flattest response with pink noise and then describe how this 'flat' response sounded subjectively with a range of musical genres. They were also asked to pick a

genre and adjust the crossover for the best subjective sound and then observe what frequency response they had created by taking a frequency response measurement.

This approach was highly successful in engaging students in the theory behind crossover networks by providing immediate visual and aural feedback to any changes in the crossover setting. It did have the drawback that students do not gain the depth of understanding of the electronics of a crossover network but it does allow them to gain a deeper understanding of the impact of changes in the crossover parameters. This was seen as a more important outcome of this activity and it allows students to appreciate the most important considerations of crossover design without necessarily having to have a deeper knowledge of the electronic principles involved. This also proved to be a good way of engaging students in evaluating and discussing sound reproduction quality issues as they could easily hear and observe the impact of phase, delay and polarity problems in an audio signal chain.
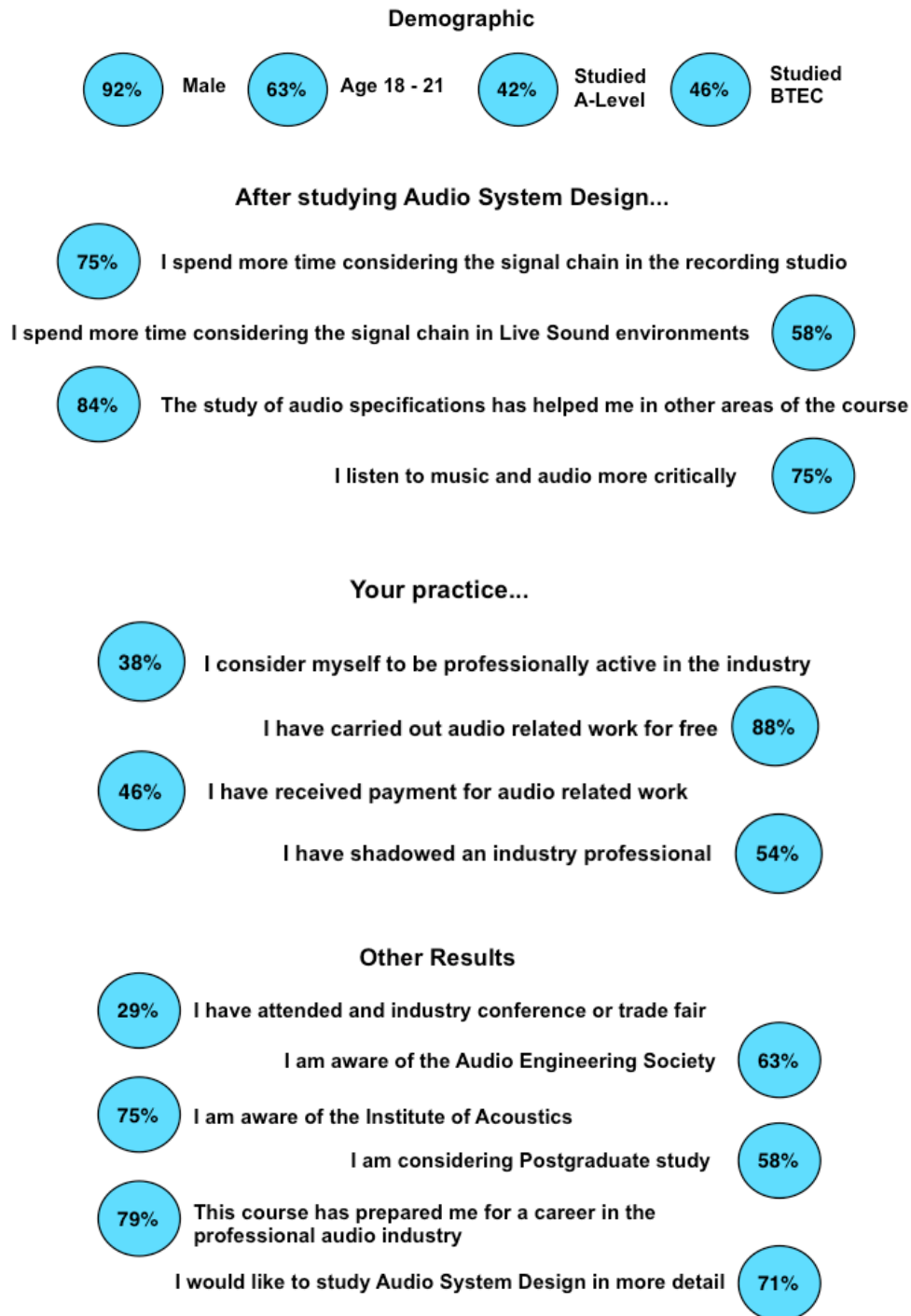
3   METHODOLOGY

The educational experiences of students studying the 'Audio System Design' module at Leeds Metropolitan University were captured through a structured questionnaire distributed and administered using Google forms. The questionnaire was divided into three distinct sections in an attempt to capture three core themes identified in the previous discussion, that of personal experience, educational impact and professional impact.

The 'personal experience' section gathered demographic information, previous levels of study and formal and informal educational experiences of sound reproduction from the respondents. The 'educational impact' section examined the initial impact the module has had on students' skills and knowledge of sound reproduction and if it had impacted other areas of the BSc (Hons) Music Technology curriculum, such as acoustics or studio recording.

Finally, the 'professional impact' section sought to determine the impact that studying the module had on students' professional practice, which included the development of skills and knowledge in relation to any professional activities they had undertaken outside of University, and whether or not students felt that studying sound reproduction would support their career in their chosen field of the creative industries.

The data was collected in the final week of the module. Informed consent was required in line with the university ethical guidelines and no names or identifiable data were associated with the results. 24 responses were received from a possible 72 students and these were used to derive the data in the results section of this paper. It is acknowledged however that there are limitations to the study, namely the incomplete response from all students and the relatively small scale of the survey, and for these reasons responses have only been used to illustrate the discussion and to highlight key points rather than draw any definitive assessment of the cohort under discussion.

4   RESULTS

Demographic

92% Male   63% Age 18 - 21   42% Studied A-Level   46% Studied BTEC

After studying Audio System Design...

75% I spend more time considering the signal chain in the recording studio

I spend more time considering the signal chain in Live Sound environments 58%

84% The study of audio specifications has helped me in other areas of the course

I listen to music and audio more critically 75%

Your practice...

38% I consider myself to be professionally active in the industry

I have carried out audio related work for free 88%

46% I have received payment for audio related work

I have shadowed an industry professional 54%

Other Results

29% I have attended and industry conference or trade fair

I am aware of the Audio Engineering Society 63%

75% I am aware of the Institute of Acoustics

I am considering Postgraduate study 58%

79% This course has prepared me for a career in the professional audio industry

I would like to study Audio System Design in more detail 71%

(Figure 4 – Results from the questionnaire)

5   DISCUSSION

The responses largely show that students acknowledge the significance of audio system design as an essential element within the broader Music Technology course. Students also generally recognise the impact of studying audio system design as it relates to further study, which is a useful outcome as it demonstrates an awareness of creating necessary links between other modules within the course such as acoustics and psychoacoustics. There were also positive responses from students who felt that the module would benefit them in the study of studio recording. This indicates that the content of the module has been adequately contextualized in order to support both the technical and creative areas of the music technology curriculum and students felt they could usefully implement what they had learnt on the module in other areas of their study.

In relation to the impact the module has had on students' personal development the results demonstrated positive indications that students spent more time considering the audio signal chain and listened to music and audio more critically. Nearly three quarters of students also felt motivated to study sound reproduction in more depth indicating a positive and engaging educational experience on the module. Of great interest to the module team were the overwhelming number of students that had previously undertaken professional audio work outside of their course, paid and unpaid. This further highlighted the necessity for the curriculum to prepare students for employment in the creative industries, however, rather than at the end of the course as Skillset suggest[5], this would be most useful throughout the duration of their studies.

6   CONCLUSION AND FURTHER RECOMMENDATIONS

This paper has highlighted the need for HE courses that include the area of sound reproduction to have a clear eye on the needs of industry and feature learning activities that engage students in realistic and industry-relevant ways. If the evidence from this study is representative of other students in HE institutions then it could be surmised that many students on these types of courses are already engaging with their chosen area of industry. Course providers will therefore need to consider ways of enhancing this sort of activity both within the curriculum and methods of teaching, which could include a requirement to undertake shadowing of professionals or location work which could also prove useful for students who are not currently engaged with industry work.

7   REFERENCES

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